Space Weather Technical Forecast

Issued on Sunday, 19 November 2023 at 01:07 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Increasing Chance of R1. Risk G1 peaking Monday 20 November and again UTC midweek.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with the background level X-ray flux recorded at GOES16 gradually increasing into low C-class. The largest flare was an impulsive M1.2 at 18/0542UTC, with a second similar flare observed at 18/1644UTC, and a third at 18/2234UTC. All of these flares appear to have originated from a large region now becoming visible on the northeastern limb.

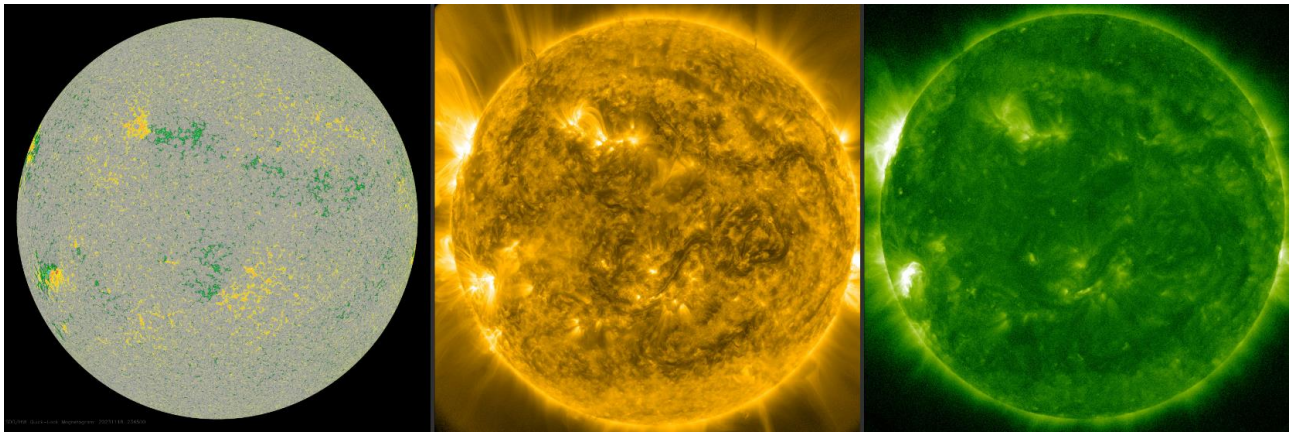

Figure 0: Solar imagery from 18/2400UTC in HMIBC; AIA171 and AIA094. Of particular note is the arriving eastern limb, with further detail likely to be revealed in the coming hours.

There are now two sunspot regions on the Earth-facing disc, with Ex-AR3486 having rotated off the disc earlier in the 24 hours. While the surviving groups are very few in number - as seen across much of the past working week - these have a very different character, being much larger and more complex than their forebears. Only the southeastern group is currently numbered, AR3489, which showed strong growth and proliferation of intermediate penumbral spots in the past 12 hours or so, with a slight areal reduction in its leading group to present as an Esi/Beta-Gamma. To the northeast, an arriving region shows a large north-south span and a large plage. This may yet be split into several groups, but currently appears as at least a Dao/Beta, and is likely to become the most complex of the two groups when fully observable.

There have been numerous Coronal Mass Ejections (CMEs) observed on imagery over the last 24 hours, with a region narrowly behind the northeastern limb proving most prolific, although no effects will be felt at Earth. More centrally and more notably, a slow filament lift-off in the southwest quadrant seen in AIA304 occurred around 18/0630UTC. There was no subsequent CME seen on coronagraphs and it is considered most likely to have been reabsorbed.

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Of potentially greater import was a small disappearing filament seen on H-Alpha imagery leaving the southeast disc around 18/1600UTC. This has been analysed and is considered most likely to pass below and behind the track of the Earth's orbit to no effect. Finally, a large prominence eruption was observed from the far southwestern octant - again to no effect at Earth. All considered, no new Earth-bound CMEs were in evidence.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE and DSCOVR at L1, have pursued a languid slow regime throughout, falling slightly from the low 300s of km/s to high-200s. The solar wind density's character was partly an artifact of switches between measuring satellites, but showed no significant departure from single figures ppcc. The IMF was steady at or below 6nT, with a north-south range of between +/-5nT. The phi angle started the period positive (away from the Sun), but switched to negative after 18/0700UTC.

The net result of the above solar wind measures was for provisionally Quiet geomagnetic activity throughout, peaking at Kp '2o' in the 21-24UTC interval.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels.

GOES16 high energy (greater than 2MeV) electron flux peaked at Moderate levels and 400pfu at 18/1825UTC. The associated 24-hour fluence has remained relatively steady and below the Active threshold (1e8 integrated pfu) threshold. The fluence observation at 19/0001UTC was 1.31e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to increase in the current UTC weekend, with an increased Chance of M-class flares from arriving northeastern limb regions in particular. A new steady state may be reached into the UTC working week.

Solar Wind / Geomagnetic Activity: There is one CME in the current forecast - the central filament from 16/0100UTC. This is due either late on day one, Sunday 19 November, or more likely in the UTC morning of 20 November. This carries a Slight Chance of Minor Geomagnetic Storm G1 peaking on Monday 20 November, but with sizeable error bars in onset time seeing a broad, flat peak that also encompasses the preceding and following UTC days.

The coronal hole forecast comprises two features - an initial weak unnumbered feature that may exacerbate the above CME should it arrive concurrently, and secondly CH73, which carries a greater chance of generating G1 midweek (UTC).

All considered, there is an initial broad, flat peak Slight Chance of G1 from the 16/0100UTC CME and perhaps a minor coronal hole. After a lull on Tuesday 21 November - perhaps the most reliably quiet day - there is then a Chance of G1 from CH73 rounding out the four-day forecast.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at Background levels.

GOES16 High energy electron flux is expected to be mostly Moderate, perhaps seeing diurnal peaks at High levels during the period. The potential CME arrival and associated geomagnetic activity may suppress observed flux levels to Normal Background into the new UTC working week. The associated 24-hour electron fluence is expected to remain below the Active (1e8 integrated pfu) level, but perhaps with an eventual increasing trend.

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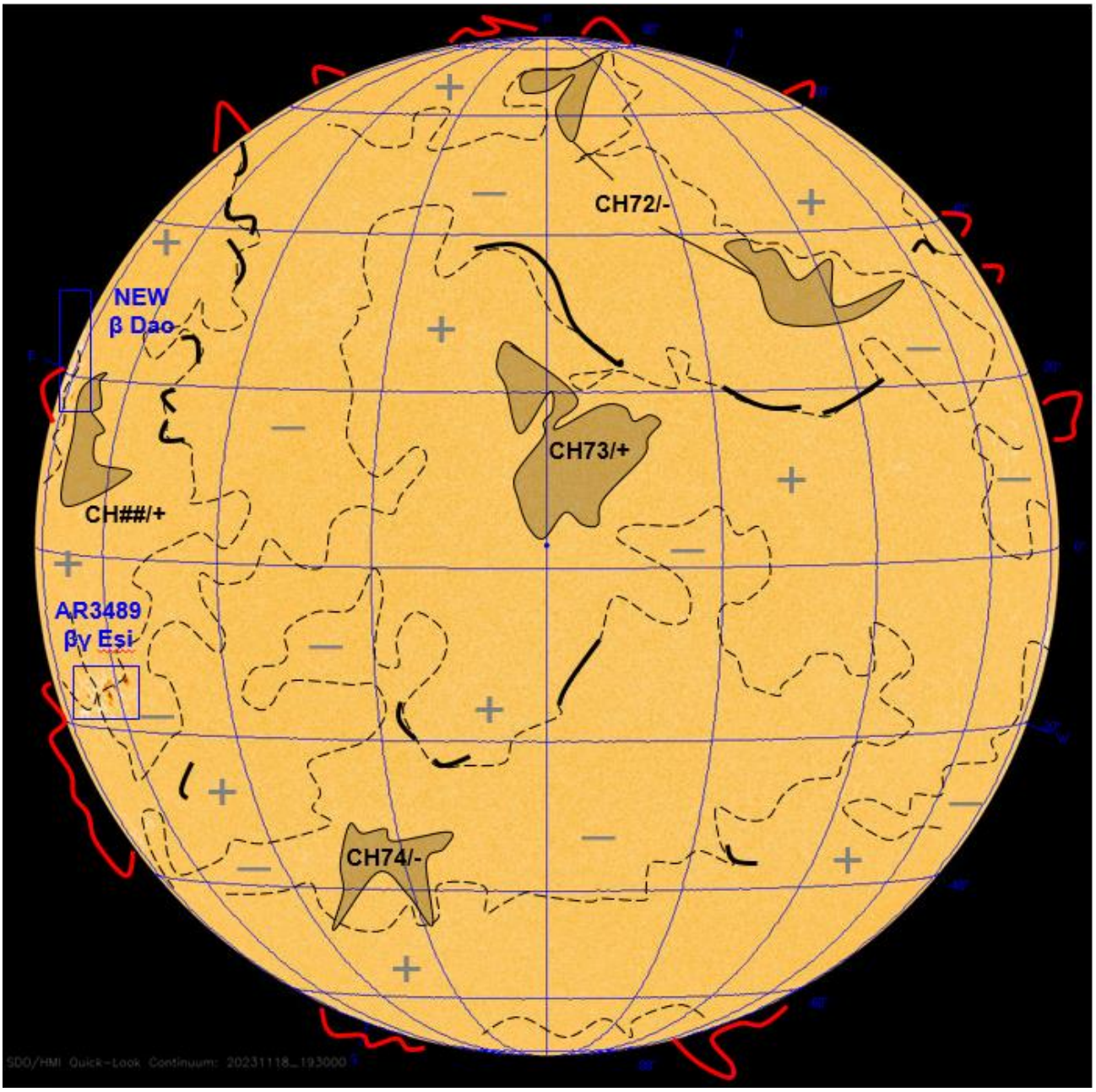
Figure 1. Solar Analysis Valid 18/1930UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is one CME that features in the forecast - the 16/0100UTC filament eruption from near centre-disc. Despite extensive analyses, the onset time of this feature remains low confidence, although confidence as to a portion of the ejecta lying on the Sun-Earth line is much higher. A most likely arrival remains in the UTC morning of Monday 20 November, perhaps 20/0600UTC, but with a broad spread of roughly +/-12 hours proffered by the MOSWOC Enlil ensemble.

Most CME activity seen on coronagraphs in the past 24 hours has apparently been tied to arriving active regions narrowly behind the eastern limb. While this does not yet factor into any geomagnetic risk to Earth, this is likely to play an increasing role by next weekend should activity persist and the active regions more directly point to Earth.

The coronal hole forecast is of relatively low significance initially, with a minor narrow coronal hole feature in the western hemisphere perhaps providing some enhancement within the first 24 hours or so, more likely should it coincide with the aforementioned CME. There is then the prospect of the larger and more intense equatorial CH73/+. This appears at a similar longitude versus last pass but is visually darker in EUV, perhaps implying a faster emanating wind of 500km/s+. Although we are nearing the winter solstice, positive features are still narrowly more potent than negative, and this coupled with its intensification mean that G1 is perhaps rated at a Chance midweek. MOSWOC Enlil does not promote any effects from this hole, with the rarefaction behind the 16/0100UTC CME perhaps delaying any onset. Whatever the reason, Enlil is felt to be lacking in this respect and the chances of G1 probably peak for the forecast period as a whole on this day.

All considered, there is an initial broad, flat peak Slight Chance of G1 from the 16/0100UTC CME and perhaps a minor coronal hole. After a lull on Tuesday 21 November - perhaps the most reliably quiet day - there is then a Chance of G1 from CH73 rounding out the forecast.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	10	20	5	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
16/1100	Partial	Filament eruption	NW central	400km/s	Late 19 into UTC morning of 20 November	Onset time low confidence, arrival in some form higher confidence

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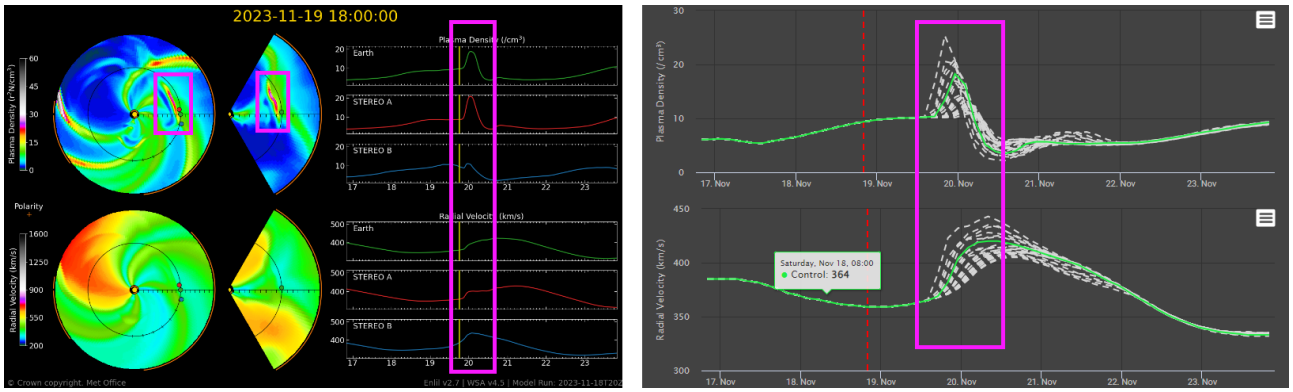
Figure 2: Latest (18/2000UTC) MOSWOC Enlil run and ensemble, showing a spread of solutions for the 16/0100UTC CME.



Radio Blackouts - X-Ray Flares:

The arriving eastern solar horizon is expected to greatly increase the risks of X-ray flare activity over the course of the current UTC weekend, with the Earth-facing side otherwise devoid of sunspots. Analysis of these arriving regions is not yet fully possible given the narrow viewing angle involved, however the unnumbered northeast limb region(s) are very likely to prove more complex than anything seen in the past week, and indeed AR3489 in the southeast, which although complex in itself and growing, saw no flares for its efforts.

The arriving 10.7cm Penticton flux is now showing a recovery to 127sfu after reaching a nadir of 116 on Thursday 16 November - itself the lowest such value since 29 November 2022 and reflective of the almost spotless disc at that time. This value is very likely to increase further into the new working week as more of the containing plage of the northeastern sunspot region(s) hoves into view, and is the rationale for the increasing but saturating Chance of M-class flares from Sunday into Monday (UTC).

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	No	40	50	50	50
Very Active	**R3 to R5 X Class**	No	1	1	1	1

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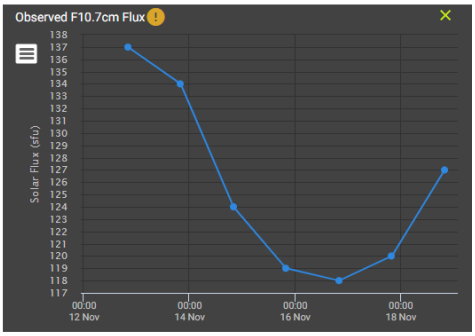
Figure 3: Past 3 days X-ray flares of C-class and above, as processed by SIDC ROB (left). Note the strong bias to the arriving eastern limb regions. Right: Past week in 10.7cm Penticton flux, showing a recent uptick that is expected to develop further into the new working week.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background levels.

The prospective arrival of at least one large and complex region over the eastern solar horizon has resulted in a relative increase in the risks of S1 compared with mid-month, however this risk remains Slight until any groups here approach the western solar hemisphere. There are no significant off-going west limb regions offering any diminishing contribution to this risk.

Radiation Storms Probability (Exceedance)	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC) (%)**	**Day 2 (00-24 UTC) (%)**	**Day 3 (00-24 UTC) (%)**	**Day 4 (00-24 UTC) (%)**
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

Any fast wind emanating from the thin unnumbered western solar hemisphere coronal hole is unlikely to greatly affect GEO electrons, with a continuation near current levels therefore expected initially. Uncertainties surrounding the 16 November CME are tied to its arrival time and not whether it will hit given its central emission location, and therefore REFM is not likely to prove useful beyond the first 24 hours, although its trend is otherwise considered accurate.

A rebound in fluence levels may show at GEO towards midweek UTC in the wake of the CME, with this likely to again be attenuated by CH73/+ through the course of Wednesday 22 November, but not before registering as a Slight Chance to start that 24-hour period. CH73 is likely to be the most significant feature in terms of electron flux and fluence in the forecast, however its effects will not be felt until later in the coming UTC working week.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	1	5	10	20
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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